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THE INTERRELATIONSHIP OF MONETARY POLICIES UNDER FLOATING EXCHANGE RATES

1. INTRODUCTION

Prior to the demise of the Bretton Woods Agreement, it was commonly believed that the greater flexibility of exchange rates under a floating regime would reduce the intervention activity of central banks, insulate domestic money supplies from the influence of U.S. monetary policy, and consequently, enable domestic monetary authorities to pursue monetary policy stances designed to achieve their fundamental domestic goal -- the provision of a non-inflationary environment for stable economic growth.[1/] It is clear, however, that monetary authorities have continued to intervene (at times quite actively) in foreign exchange markets since March 1973.[2/] Since the impact of such intervention activity on the domestic money supply can be sterilized, it is not clear, a priori, that such intervention *per se* diminishes the independence of domestic monetary policies.

The purpose of this paper is to investigate empirically the interrelationship of domestic money supplies during the floating-rate period. Specifically, the issue of whether or not intervention activity has significantly influenced the rate of domestic money growth is examined. Since the U.S. dollar remains the primary reserve currency, a simple model is developed to test the hypothesis that U.S. monetary policy (via U.S. money growth) has had either a temporary or a permanent impact on money growth in other countries.[3/] Failure to reject this hypothesis implies that, because central banks have considered their exchange rate to be an important policy objective, they may not have taken full advantage of the insulating properties of a floating exchange rate regime.

2. FLOATING EXCHANGE RATES AND CENTRAL BANK POLICY

An exchange rate is the relative price of two assets (two domestic monies) and, consequently, is determined in organized markets in the same manner as are the prices of other assets (e.g., stocks or bonds). That is, the factors that influence exchange rates are not only those factors that reflect current conditions of demand and supply in the foreign exchange market, but also, the market participants' expectations concerning what those conditions will be in the future. The fact that the assets are domestic money supplies implies that the fundamental determinants of an exchange rate include primarily the factors that affect the demands for and the supplies of domestic monies (see, e.g., [2], [4], [30], [31]). Obviously then, the monetary policies followed by each central bank and the market's perception of the directions of future policy actions play an integral role in exchange rate determination.

As is any asset's price, the exchange rate, in the short run, is influenced predominantly by "new information" which alters the market's expectations concerning future exchange rates [15]. Since "new information" typically leads to highly unpredictable and often sizable changes in exchange rates, some central banks intervene regularly in foreign exchange markets in an attempt primarily to "lean against the wind" of short-run exchange rate fluctuations in order to promote "orderly market conditions," i.e., to counteract, at least partially, the variability of exchange rates resulting from the variability of market expectations.[4/]

A. The Impact of Central Bank Intervention

Official intervention occurs when a central bank enters the foreign exchange market to buy or sell foreign currencies for the purpose of altering the current market exchange rate of its currency.[5/] In analyzing the impact of official intervention, it is necessary to distinguish those central banks' sales or purchases of foreign currencies that affect the size of the domestic money supply from those that do not. Specifically, intervention is "sterilized" if the impact of the foreign exchange operation upon the domestic money supply is neutralized by an offsetting sale or purchase of domestic assets by the central bank. Intervention activity is "unsterilized" if the foreign exchange market operation is allowed to affect the level of commercial bank reserves and, consequently, the domestic money supply.

It should be apparent that unsterilized intervention can affect the current exchange rate in at least three ways. For example, suppose the Federal Reserve intervenes, purchasing dollars with Deutsche marks (DM). First, the Fed's purchase of dollars increases the flow demand for dollars relative to the supply of dollars; this should be reflected immediately by a temporary depreciation of DM (or an appreciation of the dollar) in the short run.[6/] Second, since this transaction is unsterilized, it causes the growth rate of the U.S. money supply to fall and the growth rate of the German money supply to rise. *Ceteris paribus*, there will be an excess demand for U.S. money in the United States and an excess supply of German money in West Germany--a *stock* disequilibrium that can be rectified only if the rate of aggregate spending falls in the United States and rises in Germany. This decline in the rate of U.S. spending and rise in the rate of German spending will cause the rate of inflation in the U.S. to fall and that in Germany to rise, *ceteris paribus*, and at the same time motivate a *permanent* appreciation of the dollar. Third, market participants may interpret the decrease in the rate of U.S. money growth as a tightening of monetary policy by the Fed and, consequently, expect a further tightening by the Fed in the future. Expectations of a future tightening of U.S. monetary policy should place additional upward pressure on the current DM/dollar exchange rate as market participants anticipate further declines in the rate of U.S. inflation vis-a-vis that in Germany.

The result of a foreign exchange market operation when completely sterilized is that neither country's money supply is affected, but the composition of private portfolios is altered. That is, sterilized intervention amounts to the purchase of domestic securities with foreign securities by the central bank. Since neither money supply changes, how this type of intervention affects, for example, the DM/dollar exchange rate (at least in the long run), is less clear than in the unsterilized case. The short-run impact is essentially the same, i.e., causing relative changes in the flow demands and supplies and through changes in market expectations. However, because this intervention changes neither the monetary factors that influence the behavior of prices in the long run nor the real factors that determine the relative competitiveness of the economies and, hence, the exchange rate, it is unclear what <u>lasting</u> impact it has on the DM/dollar exchange rate.

Since sterilized intervention is ultimately a substitution of domestic securities for foreign securities (or vice versa) in private portfolios, the only way in which this type of foreign exchange market operation can have a lasting impact on the foreign exchange rate is if domestic and foreign securities are <u>imperfect</u> substitutes for each other (see [6], [19], [23], [24]). For example, the result of sterilized U.S intervention in the market for German securities is that portfolios would contain more DM-denominated securities and fewer dollar-denominated securities. If these were perfect substitutes, no change in the exchange rate or in interest rates would be necessary to motivate investors to hold this new portfolio. If, however, these securities were <u>not</u> perfect substitutes, investors would not be willing to hold the new portfolio and, in fact, an excess demand for dollar-denominated securities would ensue at the original exchange rate and interest rates. Consequently, investors would attempt to acquire additional dollar-denominated securities in order to return their portfolios to the desired proportion of dollar to DM-denominated securities, thereby placing upward pressure on the DM value of the dollar.[7/] That is, even though the two domestic money supplies would have been unaffected by the intervention activity, the resulting portfolio disequilibrium (due to the fact that foreign and domestic securities are not perfect substitutes) has a permanent impact on the exchange rate.

Because the efficacy of sterilized intervention hinges on the imperfect substitutability of foreign and domestic securities, a crucial issue is the degree of substitutability that actually exists. The conceptual foundation for the existence of imperfectly substitutable securities is that since the two securities are denominated in different currencies, actual or potential exchange-rate movements or the possibility of exchange or capital controls adds a risk factor to the holding of foreign assets that cannot be totally eliminated with a diversified portfolio (see [19], pp. 152-153). Empirical tests of the existence of this type of risk have yielded mixed results.[8/] Consequently, the contention that sterilized intervention can have a significant, lasting impact on exchange rates remains largely unsubstantiated.

B. Intervention and Monetary Policy

Unsterilized intervention is tantamount to conducting monetary policy through foreign exchange market operations. Since a country can have only one monetary policy, the role of unsterilized intervention depends critically on the importance placed on the exchange rate, vis-a-vis other economic variables, as a factor influencing the conduct of monetary policy. In particular, the use of unsterilized intervention with its concomitant impact on the domestic money supply implies that the monetary authority places relatively more importance on using monetary policy to achieve the objectives of reducing the risks and the real economic disturbances associated with exchange rate fluctuations than objectives involving the behavior of domestic prices, output and employment. Also, since the exchange rate is the relative price of two domestic monies, its movements reflect, among other things, changes in the demand for foreign money and actual and expected policy changes of foreign monetary authorities, as well as those changes emanating from within the domestic economy. Directing domestic monetary policy at an exchange rate target, then, subjects the domestic economy to both domestic and foreign influences and, consequently, lessens the ability of the monetary authority to control its own money supply independently of foreign actions and events.[9/]

The desire to influence the movement of exchange rates without losing control of the money supply is the primary rationale for using sterilized intervention. It is not clear, however, that sterilized intervention has a significant, lasting impact on exchange rates. Moreover, even if sterilized intervention does have more than a short-run effect upon exchange rates, its effectiveness in terms of its impact on the exchange rate per dollar of intervention is considerably lower than that of an unsterilized intervention transaction of the same amount (see [19], pp. 168-170 and note 6 supra). As a result, sterilized intervention may be an appropriate policy to reduce unwanted short-run variability of the exchange rate for which there may be no readily identifiable cause. When monetary authorities desire to alter the path of exchange rate movements, however, sterilized intervention may be inadequate. In this situation, monetary policymakers may have to choose between internal and external objectives (e.g., see [7]).

C. Intervention and Monetary Interdependence

There is a trade-off between monetary policy independence and exchange rate intervention which holds even if intervention is sterilized, given a stable degree of substitutability of foreign and domestic assets, if the extent of sterilization is constrained by a requirement for intervention effectiveness. To illustrate this assume that two countries, A and B, have the same equilibrium real growth rates. By purchasing power parity, the path of their exchange rate over time is determined by the relative rates of excess money growth. If country A's excess money growth is faster than that in country B, then A's domestic inflation rate would exceed B's and, eventually, the price of B's currency in units of A's currency would rise to maintain or restore purchasing power parity. Now, consider two extreme policy alternatives confronting the central bank of B. If B decides to peg its exchange rate with A, it will have to intervene consistently with the result that its money supply will grow faster than previously. In fact, the fixed exchange rate policy of B makes its money supply growth rate an endogenous variable, determined by the money supply growth rate of A. Conversely, if B chooses its money supply growth rate without regard to its exchange rate with A, it loses control of its exchange rate; the exchange rate becomes an endogenous variable determined by A's money supply growth rate relative to that chosen by B.

Obviously, there is a vast range of alternative policy mixes between the polar alternatives of pegged or freely floating exchange rate regimes. In particular, the monetary authority might reject a policy of pegging the exchange rate as impractical, but insist that its responsibilities for orderly monetary affairs require that it intervene in order to smooth abrupt exchange rate deviations or to accommodate temporary disturbances--that is, that it must lean against the wind. Such a policy would, therefore, be concerned not with the level of the exchange rate, but with its variability. Moreover, the central bank might attach asymmetric costs of adjustment in domestic credit markets and home industries to downward or upward exchange rate fluctuations, and, consequently, intervene asymmetrically. That is, the central bank might feel impelled to intervene heavily against a rise in its exchange rate, but allow the market to absorb a reduction in its exchange rate.

Three different incentives for exchange rate intervention are suggested by this characterization of central bank policy. The first motive is, simply, to maintain the exchange rate at a particular time within some band around a target or expected rate. For such a policy to be rational, however, it must be intended to move the exchange rate toward its equilibrium level more expeditiously than would the market process. This is a sensible argument only if the monetary authority has information that the market does not, primarily its planned rate of future monetary expansion (see [35]). The second motive, to lessen variability, does not presume that the monetary authority knows more than the market about the path of the equilibrium exchange rate, rather that the central bank attempts to dampen fluctuations about the market-determined exchange rate path. Clearly, this motive is a classic instance of risk aversion measured by the variance of the exchange rate and entails attempts to smooth, not to stop, movements of the level of the exchange rate (see [3] and [27]). The third motive has to do with the skewness or asymmetry of exchange rate adjustments. Unlike the second motive, the direction or sign of the fluctuation, rather than simply its magnitude, is the proximate concern. As with exchange rate levels, such a policy concern might be induced by the effect of fluctuations in the exchange rate on the current account, on short-run domestic unemployment rates or on the investment attractiveness to foreign investors. Depending on the economy, say Japan or Switzerland, this motive might suggest different policy responses.

3. A MODEL OF EXCHANGE RATE EFFECTS ON MONETARY GROWTH DUE TO CENTRAL BANK INTERVENTION

The preceding discussion of intervention, exchange rate determination, and the trade-off in domestic monetary policy has been based on an asset market theory of exchange rate determination (see [14], [15], [24], [31]). In accordance with this theory we hypothesize that any consistent policy of intervention must have, as its consequence, some loss of monetary independence. In order to test this hypothesis we will require a model which is both consistent with this approach and yet allows us to distinguish empirically the three separate motives for intervention.

To obtain such a model we first postulate that, given a steady state growth path of real output, the central bank implicitly selects its current rate of monetary growth, $\dot{M}_t^*$, by choosing a policy pair-- a desired domestic inflation rate, $\dot{P}_t^*$, and a desired exchange rate path, $g(R_t)$-- to minimize short-run fluctuations of real output around its steady state path.10/ Thus,

$$(1) \qquad \dot{M}_t^* = h(\dot{P}^*, g(R_t)),$$

where h( ) represents the optimization mapping which we assume is linear, asterisks indicate non-U.S. variables, and exchange rates (R) are in units of domestic currency per U.S. dollar. Choosing the desired inflation rate, $\dot{P}_t^*$, therefore constrains the exchange rate path.11/ Hence,

$$(2) \qquad \dot{M}_t^* = h_1(\hat{\dot{P}}_t^*) + h_2(g(R_t; h_1(\hat{\dot{P}}_t^*))).$$

For a given steady state growth path of real output, the desired inflation rate must have been implemented by a consistent growth path of money, so that the current monetary growth rate is an extension of a consistent policy,

$$(3) \qquad \dot{M}_t^* = \sum_{i=1}^{K} m_i \dot{M}_{t-i}^* + h_2(g(R_t; \sum_{i=1}^{K} m_i \dot{M}_{t-i}^*)$$

$$= \sum_{i=1}^{K} m_i \dot{M}_{t-i}^* + \hat{g}(R_t),$$

where $\hat{g}(\ )$ is g( ) rewritten to incorporate the distributed lag of money growth rates which embody the desired inflation rate, $\hat{\dot{P}}^*$.

We can then expand $\hat{g}(\hat{R}_t)$ in a Taylor series and rewrite (3) as

$$(4) \qquad \dot{M}_t^* = \sum_{i=1}^{K} m_i \dot{M}_{t-i}^* + \hat{g}(\hat{R}_t) + \hat{g}'(\hat{R}_t)(R_t - \hat{R}_t) + \frac{1}{2}\hat{g}''(\hat{R}_t)(R_t - \hat{R}_t)^2 + \frac{1}{6}\hat{g}'''(\hat{R}_t)(R - \hat{R}_t)^3 + \hat{\varepsilon},$$

where $\hat{\varepsilon}$ is the remainder of the truncated Taylor series and $\hat{R}_t$ is the exchange rate anticipated by the central bank given its choice of $\hat{\dot{P}}^*$.

To investigate the hypothesis implied in (4)--that the growth rate of money depends on deviations of the current exchange rate from its anticipated value--we need a subsidiary equation to estimate $\hat{R}_t$. Assuming that the central bank anticipates that the rate will ultimately converge to purchasing power parity, the anticipated rate can be explained by a simple monetary approach augmented by a partial adjustment mechanism as follows (see [5] and [9]):

$$(5) \ln R_t = \beta_0 + \beta_1 \ln M_t^* + \beta_2 \ln M_t + \beta_3 \ln y_t^* + \beta_4 \ln y_t + \beta_5 (i-i^*)_t + \beta_6 \ln R_{t-1} + \nu_t,$$

where y is real income, i is the three-month nominal interest rate and ν is stochastic noise.

Finally, we assume that the level of the anticipated rate, $\hat{g}(\hat{R}_t)$, and its linear deviations $\hat{g}'(\hat{R}_t)(R_t - \hat{R}_t)$, are determined by the relative growth rates of its own and U.S. money. Therefore, substituting into (4) a distributed lag of U.S. money growth for the linear terms in (4), estimating $\hat{R}_t$ with $\overline{R}_t$ from (5) and relabeling the coefficients, we obtain our estimating equation,

$$(6) \qquad \dot{M}^*_t = \alpha_o + \sum_{i=1}^{6} \alpha_{1i} \dot{M}^*_{t-i} + \sum_{i=1}^{6} \alpha_{2i} \dot{M}_{t-i} + \alpha_3(R_t - \bar{R}_t)^2$$

$$+ \alpha_4(R_t - \bar{R}_t)^3 + \eta_t,$$

where we have assumed that K in (4) is 6 (i.e., a 6-month distributed lag of money), that α_0 contains errors from the truncation ($\hat{\varepsilon}$) and η_t is stochastic noise.12/

As suggested earlier this specification presumes that exchange rate intervention may be induced by complex motivations, only one of which is the traditional attempt to fix the level of the exchange rate. Indeed, the level and, hence, sustained movements of exchange rates over time are governed by the relative output and money growth rates of the two countries, the latter of which is constrained by the choice of a domestic inflation rate. While this theory is embodied in the specification of our empirical model, so also are the other two motives, namely the reduction of variance about the exchange rate path and the asymmetric subjective valuation of exchange rate movements. These motives, if important enough to affect monetary policy, would be evidenced by significant coefficients on the squared (α_3) and cubed (α_4) exchange rate deviations, respectively, in (6). Note that, unlike the level of the exchange rate, the central bank conceivably could counter a fluctuation and, by reversing the intervention when opposing a fluctuation of the opposite sign, leave the average rate of money growth--hence, domestic inflation rate--unaffected.

4. EMPIRICAL RESULTS

Equations (5) and (6) were estimated for eight developed industrial economies which reflect a significant range of financial institutions and central bank behavior: Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland and the United Kingdom. To provide an adequate time period for adjustment to a system of floating exchange rates, the observation period begins at January 1974 and ends July 1982. The monetary aggregate used is M1. Exchange rates are those at the end of each month.[13/]

The hypothesis that foreign monetary authorities have engaged in sufficient unsterilized intervention such that U.S. money growth "causes" foreign money growth is tested from two perspectives. The first--that foreign monetary authorities <u>transiently</u> respond to changes in U.S. money growth--is examined by testing whether the individual α_{2i} in (6) are <u>jointly</u> statistically different from zero. From this perspective foreign monetary authorities are viewed as <u>temporarily</u> deviating from their desired domestic money growth path to alter exchange rate movements but eventually returning to it. Alternatively, the second perspective--that they <u>permanently</u> change their money growth rate to conform to that of the United States--is investigated by testing whether the <u>sum</u> of the α_{2i}'s in (6) is statistically different from zero. The results of these tests are reported in table 1.

From the short-run perspective, U.S. money growth has significantly influenced domestic money growth directly for Canada, Germany, Japan and the Netherlands. This result should not be a surprising one for Canada and Japan since the Canadian economy is very closely integrated with the U.S. economy and the Japanese have consistently intervened to "lean against the wind" during the floating rate period (see [33] and [37], table 1, p. 329). It may be surprising, however, that U.S. money growth affects German and Dutch money growth, especially since Germany is typically considered to be a bastion of monetary independence. On the other hand, the hypothesis that U.S. money growth has permanently affected foreign money growth must be rejected for each country.[14/]

The results of the investigation of the second and third motives for intervention--exchange rate variability and asymmetric costs of exchange rate adjustment--are also reported in table 1. Unexpected exchange rate changes were significant influences on domestic monetary growth only for the Netherlands and the United Kingdom. In each case the joint test indicates statistical significance, but more interesting is that for the Netherlands, the asymmetry test (R^3) was significant, while for the United Kingdom it was the variability test (R^2) that was significant. Since U.S. money matters for Dutch money growth, the significance of exchange rate movements causing money growth to vary is consistent. But since U.K. money growth was not significantly affected by U.S. money growth, a finding of an effect through exchange rate asymmetry may reflect the relative importance of non-monetary factors in determining the foreign currency value of the pound (e.g., North Sea oil and the general rise in world petroleum prices during the past decade).

During most of this period the United States refrained from actively intervening in foreign exchange markets, leaving that activity primarily to foreign monetary authorities. With the strong downward pressure on the dollar in 1978, however, the United States was persuaded to adopt a more activist intervention policy in November 1978 and continued to intervene frequently and in large magnitudes until February 1981. It is possible, then, that this change in policy might alter the relationship between U.S. money growth and foreign money growth. This proposition is tested by adding a multiplicative dummy to equation (6) which reflects the period of U.S. intervention.

The results of re-estimating (6) and segregating the intervention and non-intervention periods are displayed in table 2. Overall, these results are striking when compared with those in table 1. For most countries, the relationship between current and lagged domestic money growth is more significant when U.S. money growth is partitioned into intervention and non-interventionary periods.[15/] This partitioning reveals essentially <u>no</u> impact of U.S. money growth on domestic money growth during the intervention period and a <u>very strong</u> impact when the U.S. was not intervening. In particular, the F-statistic for the joint test of U.S. money growth is markedly higher for every country which was significant in table 1; moreover, U.S. money growth is revealed as a significant influence on U.K. money growth during non-intervention periods, an influence masked (in table 1) when these periods were not partitioned.

6. SUMMARY AND CONCLUSIONS

We have developed a simple model of central bank intervention in foreign exchange markets under floating exchange rates. Its foundation is the asset market approach to exchange rate determination accompanied by (1) the central bank's desire to maintain its exchange rate at a particular level or on a particular path, (2) its desire to smooth exchange rate variability, or (3) its decision to react differently to a depreciating, as opposed to an appreciating, currency.

The testing of the model yielded compelling results. Of the countries examined only the domestic money growth of France, Italy and Switzerland did not respond either to U.S. money growth or to exchange rate volatility during the floating rate period. Central banks have a choice under a floating exchange rate regime: they may insulate their domestic monetary policy from international events by allowing the exchange rate to float, or they may intervene, sacrificing to some degree their monetary independence in exchange for, perhaps, greater exchange rate stability. Switzerland, Italy and France, in contrast to the other countries in our sample, appear to have chosen monetary independence.

Given Williamson's [37] finding (see note 2), this result for Switzerland may be somewhat confusing. Schiltknecht [34], however, states clearly the Swiss National Bank philosophy:

> "Official interventions in the foreign exchange market have little impact on the money stock as long as these interventions are reversed within the next two to three months. Therefore, short-run operations in foreign exchange markets can be conducted without jeopardizing the money-stock target." (p. 77).

Moreover, it is clear that whenever the Swiss National Bank deem intervention necessary, it targets on the DM-Swiss franc exchange rate, not the U.S. dollar-Swiss franc rate (see [34, p. 78]). Indeed, when German money growth and the DM-Swiss franc exchange rate are substituted for their U.S. counterparts in the estimation of (6), the hypothesis that German money growth has a short-run impact on Swiss money growth cannot be rejected while the hypothesis that Swiss money growth is permanently affected can be rejected at conventional significance levels.

Italy's choice is consistent with Heller's observation that "countries whose inflation rates diverge greatly from that of the world average will find it difficult to maintain fixed exchange rates and will therefore adopt floating exchange rates." [22, p. 311]. During the floating period, Italy's inflation rate has generally been the highest of the developed industrial economies, and, moreover, has been higher under floating rates than under fixed exchange rates. Conversely, variability of its domestic industrial production index has been lower relative to the other countries in our sample under floating rates than under the fixed rates of the 1960s and early 1970s.[16/] Thus, without the periodic destabilizing threat of devaluation, Italy has been able to choose a domestic monetary policy of high inflation, yet have its domestic economy insulated from international repurcussions by means of a floating exchange rate.

France is also somewhat of an outlier: the growth of its domestic money supply is, according to our analysis, not influenced by U.S. monetary growth (tables 1 and 2). This result, however, is consistent with the description of French monetary policy contained in Melitz and Sterdyniak [29]:

> "In general, the regime of flexible rates has brought little change in the magnitude of the influences of money and official reserves in France. There is simply a high sensitivity to the dollar-deutsch mark exchange rate." (p. 819)

Further, Melitz and Sterdyniak report that "the basic monetary instrument is bank rate, or more precisely, the daily price of refinancing at the Bank of France" (p. 819). That is, French monetary policy is based on an interest rate target and, since deficits are directly monetized, the domestic monetary objectives apparently outweigh the exchange rate objectives.

We conclude that most central banks have considered exchange rate objectives to be an important policy goal, important enough to abandon (at least, in part) their domestic objectives of monetary policy. These exchange rate objectives have led to a causal relation between their money growth and U.S. money growth, although the linkage is primarily a short-run, not a long-run, one. That is, while our evidence indicates that U.S. money growth has a <u>temporary</u> impact on foreign money growth, there does not appear to be a <u>permanent</u> increase (decrease) in foreign money growth associated with an earlier increase (decrease) in U.S. money growth. Furthermore, we have found that U.S. intervention essentially severs this linkage. Thus, when the United States does not regularly intervene, foreign monetary growth is very strongly influenced by U.S. money growth.

FOOTNOTES

[1] The classic statement of the argument that floating exchange rates would imply monetary independence is Friedman [16]; the classic restatement is Johnson [26]. A representative critique of this argument is Branson [6]. Kenen [27] defends central bank intervention both as a short run expedient and to counter foreign asset market disturbances: ". . . insulation is achieved but only in the long run. This is true for a large class of goods-market disturbances, including some that have domestic origins. . . Insulation is not achieved, however, against a foreign asset-market disturbance, not even in the long run." (p. 410).

[2] An early observation of continued central bank activity under the floating rate regime was by Williamson [37], who argued that monetary authorities might continue to intervene under floating rates if they believed that private sector payment flows were inherently unstable; he supplied evidence supporting continued vigorous reserve activity by 9 central banks including Japan and Switzerland whose intervention activity rose under floating rates above its intervention activity under fixed rates.

[3] The form in which this model is estimated resembles the causality testing framework developed by Granger [20].

[4] See Genberg [17] and Branson [6], but note that if short-run movements of exchange rates induce central bank intervention, then empirical specifications of exchange rate models which assume exogenous money supplies are misspecified; see Caves and Feige [8].

[5] For convenience, it is assumed that all intervention operations are performed by the central bank. See [1] for a discussion of various other types of intervention operations.

[6] If the purpose of the intervention activity is to "lean against the wind," its impact may be insufficient to offset completely the effect of changes in fundamental determinants on the movement of the exchange rate. Consequently, intervention activity may not completely reverse the direction of exchange rate movements, but only slow the <u>rate</u> of change.

[7] The realignment of portfolios will, at the same time, place upward pressure on German interest rates and downward pressure on U.S. interest rates.

[8] Frankel [11, 12] finds no support at all for the existence of a risk premium. Alternatively, Meese and Singleton [28] conclude that the failure of the forward exchange rate to be an unbiased predictor of the future spot rate is a consequence of the existence of a risk premium. Finally, Obstfeld [32] finds evidence of imperfect asset substitutability, but questions the ability of central banks to exploit this limited substitutability. That is, imperfect asset substitutability appears to be a necessary, but may <u>not</u> a sufficient, condition for sterilized intervention to have a significant impact on the exchange rate.

9 The extreme case, of course, is the one in which the monetary authority desires to maintain a completely fixed exchange rate. In this case, the monetary authority has no ability at all to influence the size of its domestic money supply. See Friedman [16], Johnson [26], or Grubel [21], pp. 375-380.

10 In this context fluctuations of real output around its steady state path (over which the monetary authority has no control) act as a constraint to, rather than an objective of, monetary policy in the short run. That is, since monetary authorities cannot affect the steady state path of real output, they conduct monetary policy so as to minimize short-run deviations from this path.

11 While the underlying optimization process by which the pair $(\dot{P}^*, g(\hat{R}^*_t))$ are selected is left unspecified, clearly the central bank has chosen such a pair by the monetary policy it has undertaken, $\dot{M}^*_\tau$, $\tau = t-k, t-k+1, \ldots, t-1, t$, for which $\dot{M}^*_\tau$ is the marginal element. Each country's central bank may attach different weights to the policy consequences of its choice; hence, to model explicitly the objective functions would require more country-specific information than is necessary for the hypotheses we will be testing. (For a fuller development of the explicit central bank choice, see Batten [3]). For our purposes here, it is sufficient to postulate the optimization process and to make use of the implied constraint on the policy choice imposed by the tradeoff between the domestic inflation rate and the time path of the exchange rate. Thus, in our development of the model, we could equivalently have taken the alternative tack of selecting the exchange rate and then choosing the domestic inflation rate given the chosen exchange rate path.

12 A three-month moving average was used for the money growth rates. Month-to-month growth rates were used initially, but fluctuations were so great as to preclude meaningful interpretation. Distributed lags of U.S. and domestic industrial production growth were also included in (6). Without exception these variables did not add any explanatory power to the equation. Furthermore, while the transformation from (3) into (6) removes a large part of the problem of simultaneous equations bias--i.e., the jointness of determination of exchange rate and foreign money--the problem may still be present in the non-linear terms, the squared and cubed deviations of the exchange rate. This problem is addressed in two ways. First, using a modified Granger-causality testing procedure (see [10]), we found no support for the hypothesis that foreign money growth "causes" U.S. money growth. Second, since U.S. money growth, inter alia, causes exchange rate movements, the auxilliary equation, (5), makes our model essentially a two-stage least squares procedure. Moreover, the exchange rate variables

included in (6) are deviations from the expected exchange rate. Consequently, since expected exchange rate movements are caused by money growth, it is unlikely that unexpected movements would also be caused by money growth.

13 End-of-month rather than average-over-the-month exchange

rates were used to conform to the anticipated exchange rate, $\bar{R}$, estimated in the instrumental equation (5). In that equation, the production index for each country is a flow so that its interpretation as average or end-of-month is somewhat ambiguous; however, the money stocks and forward premia are end-of-month observations (monthly averages are not available) so that the end-of-month exchange rate is the datum most consistent with the explanatory variables.

14 It has been suggested that our results simply reflect a coordinated response by monetary authorities to real shocks (primarily oil shocks) that have occurred during the floating rate period. First of all,a general and consensus response to real shocks implies a permanent, not a temporary, relationship between monetary growth rates. Since no permanent relationship is found, this hypothesis does not appear to be supported by the data. Second, if real shocks have had a significant impact on monetary policies, one would expect changes in the growth of industrial production to be an important determinant of money growth. The fact that industrial production growth, when added to (6), was statistically insignficant (see footnote 12), however, does not support this contention. A final confrontation of this hypothesis was conducted by adding the growth rate of U.S. refiners' acquisition price of oil expressed in domestic currency units and alternatively, expressed in U.S. dollars to (6). A variation of this was to weight the price of oil by the gap between domestic energy production and consumption. None of these 4 experiments altered the qualitative results reported here.

15 The variability of the exchange rate measures, which are not reported in Table 2, were uniformly insignificant during periods of U.S. intervention; during non-interventionary periods, the asymmetry measure was significant for the Netherlands and the United Kingdom, while the variability measure was significant for Switzerland, all at the 5 percent level.

16 The variability of real output (measured by the coefficient of variation of the growth rate of industrial production) was higher for all the countries in our sample during 1974-1982 than it was during 1962-1971. A likely explanation for this in that rapidly rising oil proces during the 1974-1982 period has lowered real output growth significantly for all countries. For Italy, even though its average annual rate of real output growth declined from 7.2 percent to 2.7 percent, its coefficient of variation increased proportionately less than that of any country in

our sample. In fact, on an absolute basis, Italy's coefficient of variation is smaller than that of any country except Japan for the 1974-1982 period.

Table 1

TEST STATISTICS FOR HYPOTHESIS THAT U.S. MONEY GROWTH OR EXCHANGE RATE DEVIATIONS INFLUENCE FOREIGN MONEY GROWTH[1/]

	Domestic Money Growth Dates		U.S. Money Growth Rate		Exchange Rate Deviations		
Country	Joint	Sum	Joint	Sum	Variability	Asymmetry	Joint
Canada	12.13*	.37	4.13*	1.02	.77	-1.09	.65
France	22.50*	5.50*	.36	.01	-.36	.68	.23
Germany	14.87*	55.77*	2.76*	1.02	.50	.46	.16
Italy	12.36*	23.02*	1.50	.26	.42	1.21	1.01
Japan	8.46*	8.84*	1.96*	2.43	-.25	-.27	.06
Netherlands	25.46*	52.47*	2.36*	1.01	-.88	4.13*	9.34*
Switzerland	19.59*	29.42*	.83	.02	1.14	-.47	.65
U. K.	18.64*	46.58*	1.00	.01	-2.18*	.85	2.59*

1/ F-statistics on estimates of equation (6) for null hypothesis that each and every coefficient is zero (Joint) or that the sum of the coefficients is zero (Sum). An asterisk denotes significance at the 5 percent level.

Table 2

TEST STATISTICS FOR HYPOTHESIS THAT U.S. MONEY GROWTH AND EXCHANGE RATE DEVIATIONS AFFECT FOREIGN MONEY GROWTH PRIMARILY WHEN U.S. DOES NOT INTERVENE 1/

	Domestic Money Growth Rate		U.S. Money Growth Rate			
			Intervention Period		Non-Intervention Period	
Country	Joint	Sum	Joint	Sum	Joint	Sum
Canada	12.81*	.74	1.99	.14	4.74*	1.02
France	23.01*	6.73*	.52	.07	1.04	.00
Germany	14.53*	56.28*	1.10	.43	3.84*	.00
Italy	7.22*	6.96*	.94	.03	.72	.00
Japan	7.70*	12.72*	.74	.12	2.04*	1.30
Netherlands	22.95*	46.48*	.33	.97	2.41*	.90
Switzerland	17.33*	31.50*	.22	.29	1.46	.08
U.K.	21.62*	53.79*	1.50	1.60	2.49*	.02

1/ F-statistics on estimates of equation (6) for null hypothesis that each and every coefficient is zero (Joint) or that the sum of the coefficients is zero (Sum) modified by addition of multiplicative dummy variables on U.S. money growth rates during the period of active U.S. intervention (November 1978-February 1981). An asterisk denotes significance at the 5 percent level.

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